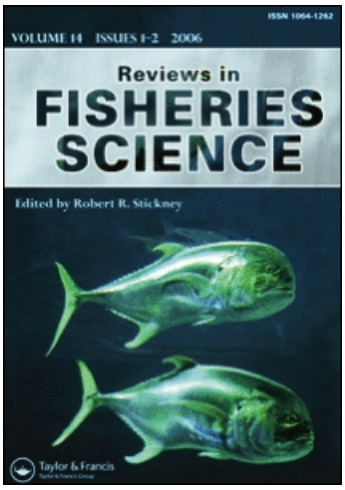

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Robert L. Shipp [a]; Stephen A. Bortone [b]
[a] Department of Marine Sciences, University of South Alabama, Mobile, Alabama, USA [b] Minnesota Sea Grant College Program, Duluth, Minnesota, USA

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A Perspective of the Importance of Artificial Habitat on the Management of Red Snapper in the Gulf of Mexico

ROBERT L. SHIPP[1] and STEPHEN A. BORTONE[2]

[1]Department of Marine Sciences, University of South Alabama, Mobile, Alabama, USA
[2]Minnesota Sea Grant College Program, Duluth, Minnesota, USA

The Gulf of Mexico red snapper fishery has been declared as overfished, and overfishing is occurring. More stringent regulations, including reduced catch quotas and restrictions on the shrimp fishery to reduce bycatch of juvenile snappers, are anticipated. However, with projected rebuilding, maximum sustainable yield (MSY) is estimated to be between 11 and 25 million pounds. This exceeds previously recorded annual yields from U.S. Gulf waters. The fishery began during the mid 19th century off the northeastern Gulf coast, with harvests of only about 2 million pounds. Even at this rate, the stocks were depleted rapidly, and the fleets moved further south and east to find new sources. Numerous exploratory cruises to the western Gulf in the late 19th century found minimal snapper populations, but high concentrations discovered off Vera Cruz, Mexico, attracted fishers, and this area was the major source of snappers for more than a century. The deployment of petroleum structures in the mid 20th century in the western Gulf and thousands of artificial reefs in the north-central Gulf have markedly increased red snapper habitat in those areas. Currently, snapper populations around artificial reefs in the north-central and northwestern Gulf support the majority of the U.S. harvest. If habitat is limiting, the designations of "overfishing" and "overfished" may be misleading, and "unrealized harvest potential" may be a more accurate descriptor of the current status of the stock given the increased presence of additional habitat for red snapper. Decreases in these artificial structures (owing to natural degradation or removal) may decrease future harvest potential.

Keywords red snapper, artificial habitat, overfishing, management

INTRODUCTION

Red snapper (*Lutjanus campechanus*) stocks in the Gulf of Mexico (Gulf) have been declared overfished and overfishing is occurring (SEDAR7, 2005). Currently, the Gulf of Mexico Fishery Management Council (GMFMC) is in the 13th year of a 29-year rebuilding plan designed to remove both designations from this valuable resource. Although there are numerous regulations currently in place to aid in stock recovery, projections are that recovery by the target date of 2032 may not occur unless additional restrictions are imposed. An additional reduction in the total allowable catch (TAC) is under consideration and will impact the directed red snapper fishery. The TAC for the years 2001–2006 was set at 9.12 million pounds (mp) about equally divided between recreational and commercial harvest. Additional reductions were imposed in 2007, reducing quotas to less than 6 million pounds. These have resulted in shorter seasons, smaller bag and trip limits, and other related actions. In addition, there is a high mortality of age 0 and 1 juvenile snapper caused by trawl bycatch in the Gulf penaeid shrimp fishery. Thus, additional actions are under consideration to reduce bycatch, including areal and seasonal shrimp fishery closures (GMFMP, 2006). These suggested actions are being contemplated under the assumption that the red snapper fishery is currently recruitment limited.

Model projections of maximum sustainable yield (MSY) for Gulf red snapper stocks are between 11.3 and 25.4 mp annually (SEDAR7, 2005). These constitute a marked reduction in hypothetical MSY from previous annual assessments. In earlier assessments, some MSY projections ranged between 40 and 60 mp, and the 1999 stock assessment projected an MSY of 205 mp (GMFMC, 2004). The current smaller estimates reflect a "more realistic" estimate of MSY, but they remain far in excess of the actual historical landings for red snapper in the Gulf of

Address correspondence to Dr. Robert L. Shipp, Department of Marine Sciences, University of South Alabama, Mobile, AL 36688, USA. E-mail: rshipp@jaguar1.usouthal.edu

Mexico. Although data from early years of the fishery are few and often subjective, the highest landings before 1970 were approximately 9 mp, and, in most years, landings were about 5 mp. Landings from the eastern Gulf of Mexico averaged more than double those from the western Gulf until the late 1950s when landings from both regions were similar until the mid 1960s, from which time western Gulf landings began to exceed those from the eastern Gulf and continue to do so (SEDAR, 2007; RW-4:11).

This review briefly describes the history of the Gulf red snapper fishery and then describes the factors which may be responsible for the demographic changes in snapper stocks. These factors likely explain the geographic shift in catches from the eastern to the western Gulf. This has relevance to the management of the stock and may result in changes in our understanding of the stock's limiting factors and model projections of stock characteristics.

HISTORY OF THE SNAPPER FISHERY: THE FIRST 100 YEARS

The Gulf of Mexico red snapper fishery began in the mid 19th century off the Florida panhandle and Alabama coasts. Until the availability of affordable ice (around 1869; Collins, 1887; Bortone et al., 1997), the fishery was limited to small vessels from New England, known as "smacks" because their live wells created a smacking sound of water (but, see Bortone et al., 1997, wherein the term may be a phonetic spelling of the Dutch name for these boats.) These vessels were limited to catches of 5,000 to 6,000 lb. With the availability of ice, catches well in excess of 20,000 lb became possible, as did longer voyages. The early history of the fishery, as well as the status of the fishery to the mid 20th century has been well documented by Camber (1955) and Bortone et al. (1997).

A more detailed and revealing review of the early fishery was provided by Collins (1887) in a report to the U.S. Commission of Fish and Fisheries. He reported that the specific area between Mobile, Alabama, and Ft. Walton (then Camp Walton), Florida, constituted the origin of the fishery. He further noted that stock depletion was evident even in these early days of the fishery:

> The character of the snapper grounds, so far as relates to abundance of fish on them, and, of course, their consequence importance, has changed very materially, it is said, within the past three or four years.
>
> It is claimed that this change is still going on, and that localities that were remarkable for the abundance of fish on them only a year or two ago are now of comparatively little importance. The best evidence that can be adduced in support of this theory is the fact that the vessels are continually obliged to extend further off in order to meet with success, and at present we are told that it would be of little use to attempt to catch fish on grounds where they could be taken in great numbers in the early days of the business (Collins 1887:281).

Collins also mentioned that total annual catches were about 2 mp.

Collins (1887) alludes to rumors about snapper stocks off Campeche and Vera Cruz, Mexico, but this major source of red snapper was unknown at this time. However, exploratory voyages were being made in search of new red snapper grounds. Particularly, the western Gulf received much exploratory effort in the 1880s:

> It may not be out of place to say that quite extended researches have been made west of the Mississippi in search of snapper banks, the demand for fish in the Galveston and New Orleans markets, and the consequent high price often being paid, no doubt, an inducement toward making these investigations. As early as the fall of 1880, two smacks from Noank Conn., which were fishing in the Gulf, made a cruise off Galveston in search of fishing grounds, but found no bottom suitable for red snappers to live on. Mr. Sewell C. Cobb also tells us that he spent the entire month of July, in 1883, seeking for red snappers, and sounding along the coast, from the southwest pass of the Mississippi to a point off the center of Padre Island, Texas, a distance of about 450 miles. The bottom, over all this extent of ground, was mostly mud and broken shells, and totally devoid of any fish life, as far as he could tell.
>
> In the summer of 1884 the Pensacola Ice Company sent another schooner off Galveston for red snappers, but the voyage was a failure, the vessel not getting enough fish to pay her provision bill (Collins 1887:280).

Collins also noted that the catches were dominated by relatively large fishes, often averaging ten pounds or more (Figure 1).

Following the Collins (1887) review, additional reviews of the snapper fishery in the 19th century were provided by Smith (1895) and Warren (1898), both describing the large catches off Campeche. During the early part of the 20th century, Jordan and Evermann described the snapper fishery as follows: "Its centre of abundance is in the Gulf of Mexico in rather deep water in the rocky banks off the west coast of Florida and the coasts of Campeche and Yucatan" (1923:410). Gowanloch described the location of the snapper fishery: "The center of this fishery lies east of Louisiana" (1933:193). But, perhaps the most comprehensive review of the first century of the fishery was contributed by Camber (1955). While a detailed discussion of this work is beyond the scope of this paper, Camber's summary of the fishery is extremely revealing. For example, there are five references to the fishery off the west coast of Florida, seven to the fleet fishing off Campeche, and not a single reference to the north central Gulf west of Alabama and westward to Texas, despite the fact that much of the fleet claimed Mobile, Alabama, New Orleans, Louisiana, and Galveston, Texas, as their home port. Camber does mention that "some of the larger vessels

Figure 1 A late 19th century catch of red snapper landed at the port of Mobile, AL (USA Archives).

which normally fished Campeche occasionally also visited the 'Galveston Lumps'. However, not many captains in Pensacola and Mobile were familiar with that poorly charted area, and, until depth recorders became available, the number of trips made was small" (1955:48).

Camber provided a figure of the areas fished by the snapper fleet during those first 100 years, and it includes an area from the mouth of the Mississippi River westward to an area south of Galveston, termed the "Western." However, he made sparse reference to this area, noting that it was "all points within 10 miles on both sides of the 100 fathom line, between latitude 29.20 and longitude 89.20 and 98.00" (Camber, 1955:13). In addition, the Galveston snapper fleet was described in 1939 as spending from 14 to 25 days at sea with boats that "frequently sail to the Campeche shoals, although there was some hard bottom as close as 30 miles from shore" (Camber, 1955).

The importance of the Campeche fishing ground is reflected throughout the body of the Camber work and is summarized in his Table 16. Red snapper catches from Campeche comprised about 75% of the landings reported from Pensacola and about 50% of the landings reported from the Florida West Coast.

Thus, it appears that the major red snapper fishing grounds from the industry's inception in the mid 19th century until the mid 20th century was off the west coast of Florida, the Florida Panhandle, and the Campeche grounds, with relatively few landings off Mississippi and westward and southward to the Texas-Mexico border.

DEMOGRAPHIC CHANGES IN SNAPPER STOCKS DURING THE LAST 50 YEARS

The SEDAR7 (2005) red snapper stock assessment chronicled the historical landings of the U. S. red snapper harvest from U.S. Gulf waters from 1880 to 1970. These landings are in agreement with the above review of the fishery. From 1880 to about 1950, the harvest was principally from the eastern Gulf and Campeche. Total catch from these areas averaged about 3.5 mp annually, with a maximum annual catch of 6 mp around 1900. Catches during this period from the western Gulf were generally less than 1 mp. Red snapper catch changed radically in the 1950s, with the harvest from the western Gulf of Mexico equaling that from the eastern Gulf during this decade. By 1970, the red snapper catch from the western Gulf (about 5 mp) nearly doubled that from the eastern Gulf (Figure 2). More recently, the red snapper catch from the western Gulf is currently estimated 6 to 7 times greater than the catch from the eastern Gulf in terms of virgin biomass (SEDAR 7, 2005; RW-4:3).

Interestingly, red snapper catches off Alabama have dominated the recreational harvest in the Gulf, even though this area represents less than 5% of the U.S. Gulf of Mexico continental shelf. The recent catch of red snapper off Alabama represents an estimated 40% of the total recreational catch from the Gulf of Mexico (Figure 3), which is nearly equal to the total annual catch of red snapper from the Gulf in the 1880s.

HABITAT CHANGES IMPACTING SNAPPER STOCKS DURING THE LAST 50 YEARS

In 1947, "Block 32," southeast of the northeast coast of Texas brought in a gusher of oil, and the full-scale exploration for petroleum in the northwestern Gulf of Mexico had begun (Yergin, 1991). Over the next several decades, more than 4,000 platforms were deployed in the relatively shallow shelf area of the region, markedly transforming the available habitat in the Gulf (Figure 4). Currently, there are approximately 3,900

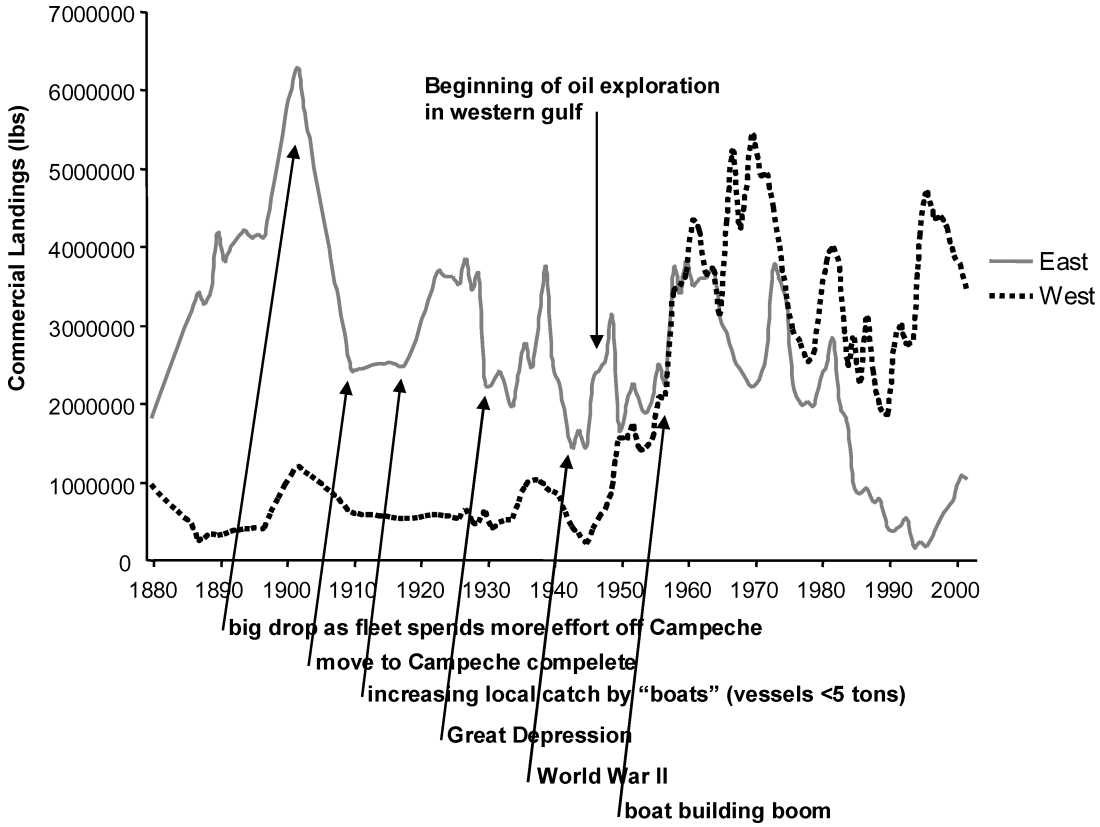

Figure 2 Reconstructed landings of red snapper caught in the U.S. Gulf of Mexico (east or west of the Mississippi River) for the years 1880–2003. Arrows connect trends with important historical events. Arrows from below are after Porch et al. (2004) (data 1880–1962), Poffenberger and Turner (2004) (data 1962–2003), and arrow from above from Yergin (1991).

oil platforms still standing, with about an equal number (approx. 100) being constructed and decommissioned annually (R. Kasperzak, Louisiana. Dept. of Wildlife and Fisheries, personal communication). Wilson et al. (2006) detailed the value of oil platforms as artificial reefs, concluding that they support fish densities 10 to 1,000 times that of adjacent sand and mud bottom, and almost always exceed fish densities found at both adjacent artificial reefs and natural hard bottom.

Off Alabama, an artificial reef program was initiated in 1953 when the Orange Beach Charter Boat Association began depositing reef materials off that state's coast. In 1974, retired U.S. Navy "liberty ships" were deployed at five locations in 24–28 m of water. In 1987, the U.S. Army Corps of Engineers issued a general permit to the Alabama Department of Conservation for reef siting off the Alabama coast. This permit is still extant and covers more than 1,200 square miles (3,108 km^2) of continental shelf bottom in depths of approximately 20–90 m. Altogether, an estimated 20,000 artificial structures have been placed in this area (MRD, 2006). Previous to this reef deployment activity, the permit area was primarily sandy mud with

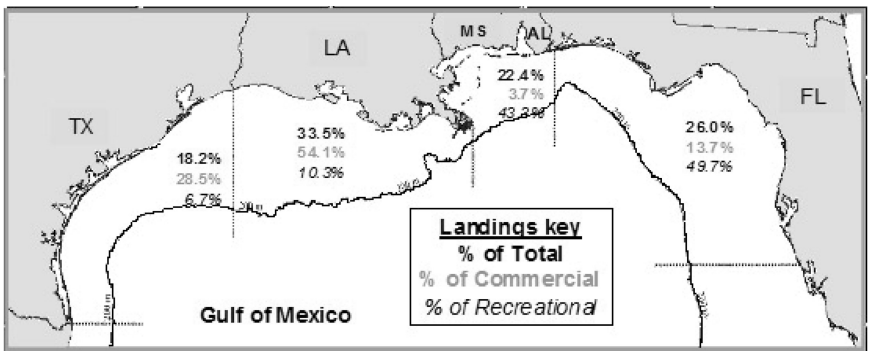

Figure 3 Geographical distribution of average commercial, recreational, and total landings of red snapper caught in U.S. waters in the Gulf of Mexico for harvest years 1999–2002 (National Marine Fisheries Service—MRFSS and Headboat Statistics and Texas Parks and Wildlife Recreational Survey Statistics).

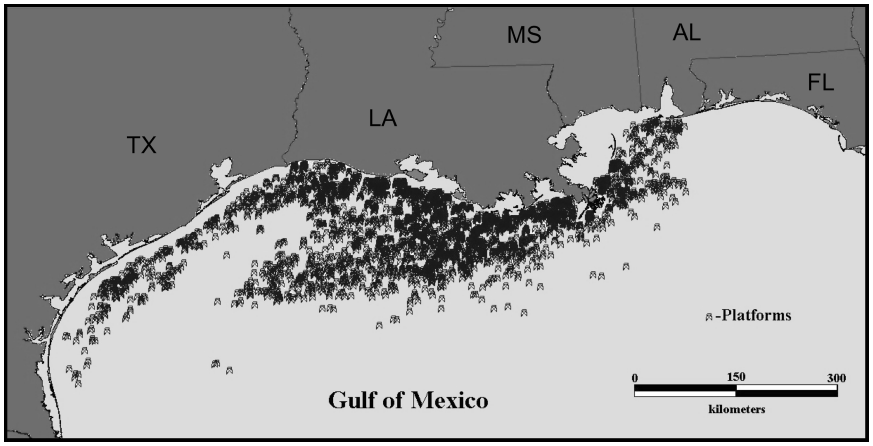

Figure 4 Cartoon representing recent (1990–2000) locations of operating petroleum rigs in the Gulf of Mexico (Minerals Management Service Statistics).

limited hard bottom, nearly all of which was of low relief and dominated by diminutive fish species, chiefly sparids, serranids, and pleuronectids of negligible economic value (Shipp, 1999).

Although the two habitat alterations described above are by far the most extensive in the Gulf of Mexico, supplementary additions of hard bottom through the permitted deployment of artificial reefs, including oil drilling platforms, have occurred in every Gulf state. While the fish demographic changes may vary, each state has expanded its artificial reef program in recent years, chiefly to enhance red snapper stocks (L. Simpson, Gulf States Marine Fisheries Commission, personal communication).

DISCUSSION

The debate regarding the status of red snapper stocks in the Gulf of Mexico is ongoing. Current models and assessments indicate these stocks in the Gulf are overfished and that overfishing is occurring (SEDAR7, 2005). The assessment models are based on the premise that red snapper stocks are recruitment limited, but there remains considerable uncertainty in the stock-recruit relationship. Of interest, the SEDAR7 (2005) report concludes that, for more than a decade, recruitment levels have been far greater than would be expected from the estimated stock size. In fact, estimated recruitment since 1985 was, on average, higher than virgin recruitment despite the stock being estimated as highly depleted.

The information presented above suggests that habitat may be an important factor regulating stock size. Evidence indicates that massive areas of the northern and northwestern Gulf of Mexico were essentially depauperate of snapper stocks for the first 100 years of the fishery. Subsequently, areas in the western Gulf have become the major source of red snapper, concurrent with the appearance of thousands of petroleum platforms and other artificial reef deployments. This information argues persuasively for a reevaluation of the importance of habitat as a limiting factor for red snapper. Similarly, addition of an extensive artificial reef network on the near-shore continental shelf off Alabama has transformed the area from a relatively unproductive area for red snapper to one of the most productive red snapper areas in the Gulf of Mexico. The hypothesis that red snapper are habitat limited appears reasonable, especially if the alternative is to accept the idea that a grossly depleted stock is producing higher recruitment than the virgin stock.

When one discusses these habitat modifications, the issue of attraction versus production is inevitably raised. One of us (RLS) discussed this issue at length (Shipp, 1999), and contended that, for the area off Alabama, an increase in total biomass was not what was relevant. Rather, it was the transformation of the substratum from a predominantly sandy mud habitat to one having increased areas of hard bottom with high relief that relieved the "bottleneck" that had previously prevented red snapper from increasing in abundance.

Osenberg et al. (2002) indicated that artificial reefs can offer some species an opportunity for expansion if the artificial reef provides a means for relief from a "bottleneck" on life-history features. Bortone (2008) presented a model that explains the advantage that artificial reefs may have in providing both attraction and production benefits to fishes that comprise demersal fisheries like red snapper. Artificial reefs may attract fish but, in addition, they may also provide increased habitat that relieves a "bottleneck" in the life history that previously restricted population abundance.

One may ask if it is simply a result of attraction, where are the snappers attracted from? There are no areas of the Gulf that have become less productive for red snapper in recent decades. And, in fact, (1) recent landings data (1999–2002) from the Florida west coast (Figure 3), when compared to landings data (1995–1999) provided by Schirripa and Legault (1999); (2) testimony by reputable commercial fishermen at GMFMC meetings (March, 2006), and (3) testimony by a NMFS scientist at the GMFMC meeting (November, 2006) using fishery independent methods all support the view that red snapper stocks in that area are increasing. In addition, mark-recapture data from recent studies off Alabama (Watterson et al., 1998; Patterson

et al., 2001) demonstrated a prevalent west to east movement of red snappers from the Alabama area to the Florida panhandle and beyond.

Further evidence for the habitat limitation hypothesis rather than purely attraction was provided by Szedlmayer and Shipp (1994). They demonstrated a marked increase in abundance of early juvenile (age 0) red snapper within the Alabama artificial reef permit area following large-scale reef placement. Thus, the increased population in this area was likely attributable to a habitat-related recruitment increase and not a result of migration from other areas.

One might also contend that during the early red snapper fishery in the Gulf of Mexico, the technology to locate additional hard bottom and the unexploited stock was unavailable. Had such technology existed, and had additional habitat been located, the relatively small annual landings of around 2 mp at the fishery's inception would not have depleted the entire stock. However, the recent tag-recapture studies cited above also demonstrate that red snapper stocks are redistributed during tropical cyclones. Data from 1872 to 1889 record landfall of 11 hurricanes between Gulfport and Pensacola (Dr. A. Williams, Department of Meteorology, University of South Alabama, personal communication). This is the precise area of the fishery's origins. Thus, occurrences of these storms would have replenished red snapper to the few known hard bottom areas from the more extensive but uncharted surrounding areas, had they existed.

CONCLUSIONS

The massive additions of artificial reef habitat preferred by red snapper during the last 50 years in the north-central and northwestern Gulf of Mexico has corresponded with major shifts in harvest locations and areas of red snapper concentrations. This suggests that habitat was a factor that limited population abundance during the first 100 years of the fishery. Current model projections of MSY at levels higher than have ever been achieved also suggest that increases in habitat have increased harvest potential. However, because current models are premised on a stock of red snapper that is recruitment limited, these stocks are considered "overfished, and overfishing is occurring." Consideration of increased habitat would lead to a different conclusion (i.e., the stocks have an unrealized harvest potential).

In addition, if the habitat limitation hypothesis is correct, it will be necessary to maintain, or even increase the amount of artificial habitat in the northern Gulf of Mexico to keep pace with fishing pressure. Programs such as the "rigs to reefs" efforts off Louisiana and Texas would have to be continued, as would the reef construction off Alabama.

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